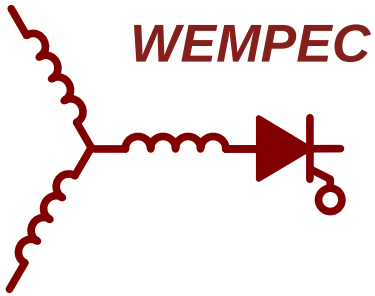
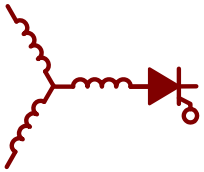


Electrical Systems and Loads for Sustainable Buildings

Dr. T.M. Jahns

University of Wisconsin - Madison

February 3, 2009



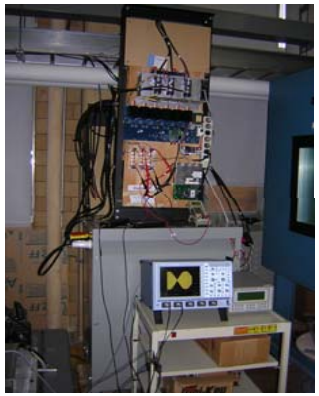
WEMPEC

Wisconsin Electric Machines and Power Electronics Consortium

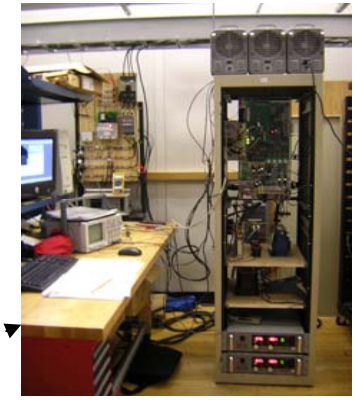
- University-industry consortium devoted to pre-competitive research in power electronics, motor drives, and electrical systems
  - >65 sponsors, including equipment manufacturers, component suppliers, and system users
- Founded 28 years ago
- 6 Professors working together on multi-disciplinary research
  - Over 40 years of industry experience
- More than fifty graduate students, M.S. & Ph☐.D.
- Shared lab space and largely common course sequences

UW Microgrid Testbed

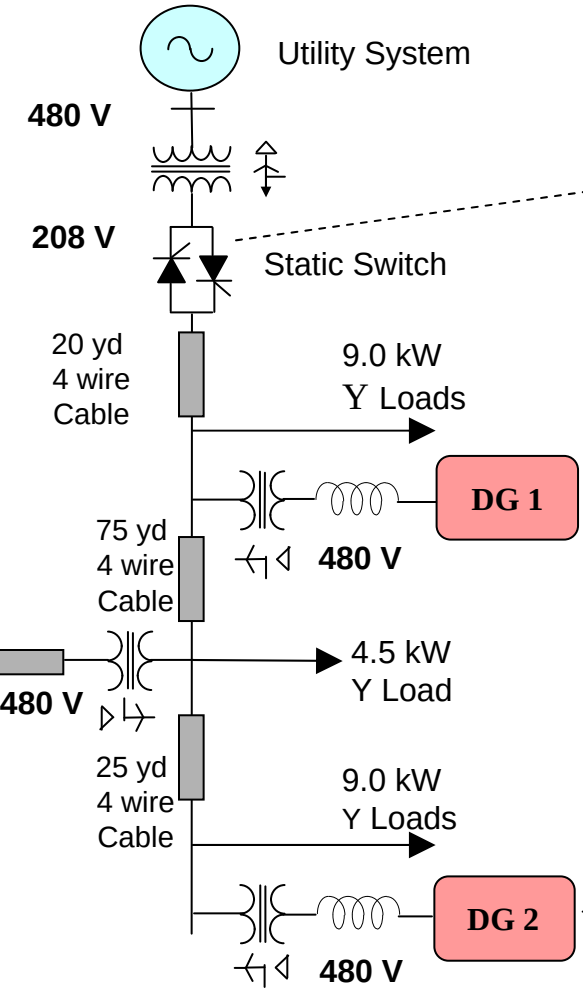
Diesel Genset



Static Switch

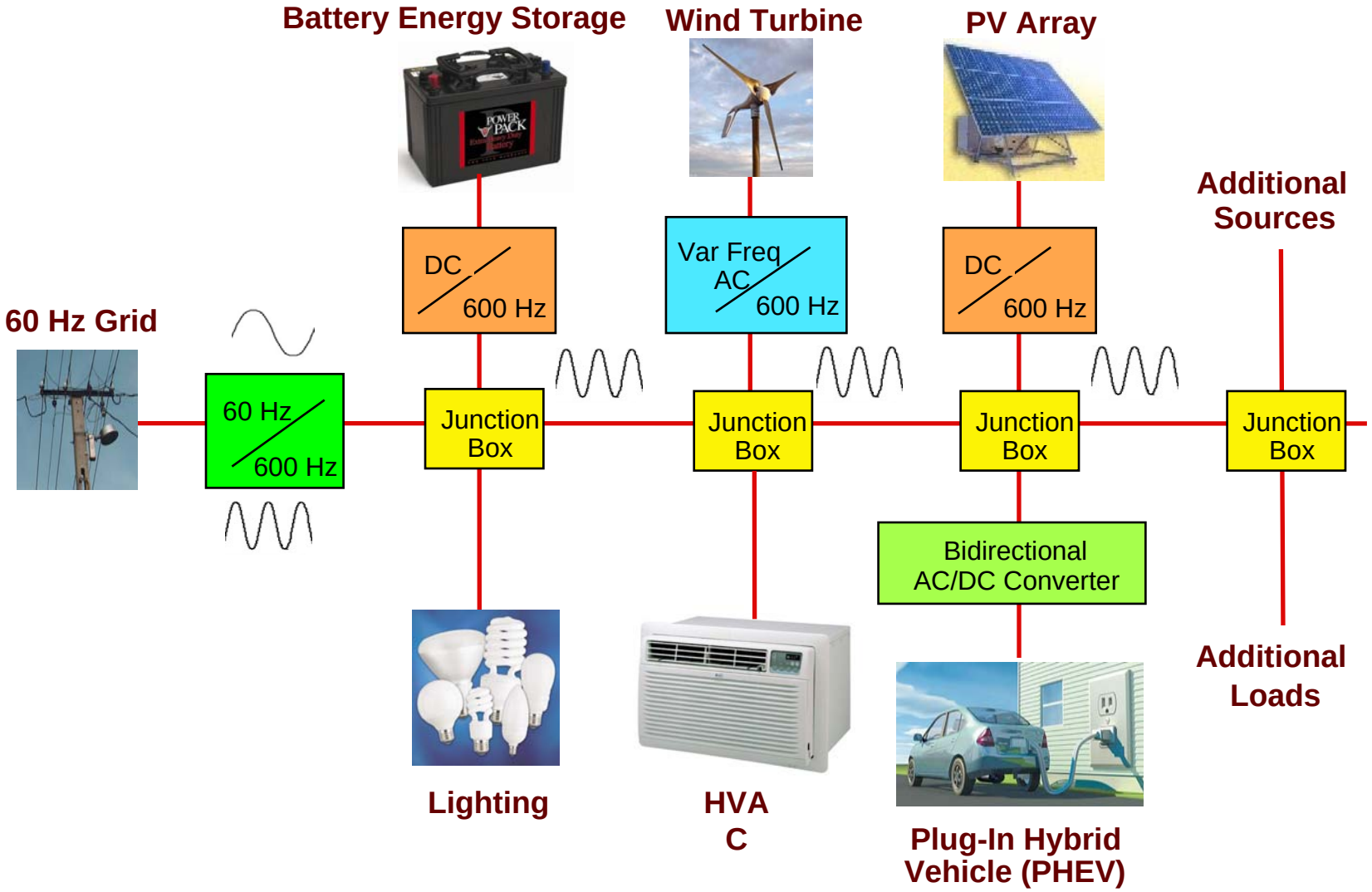


Inverter-Based Microsources



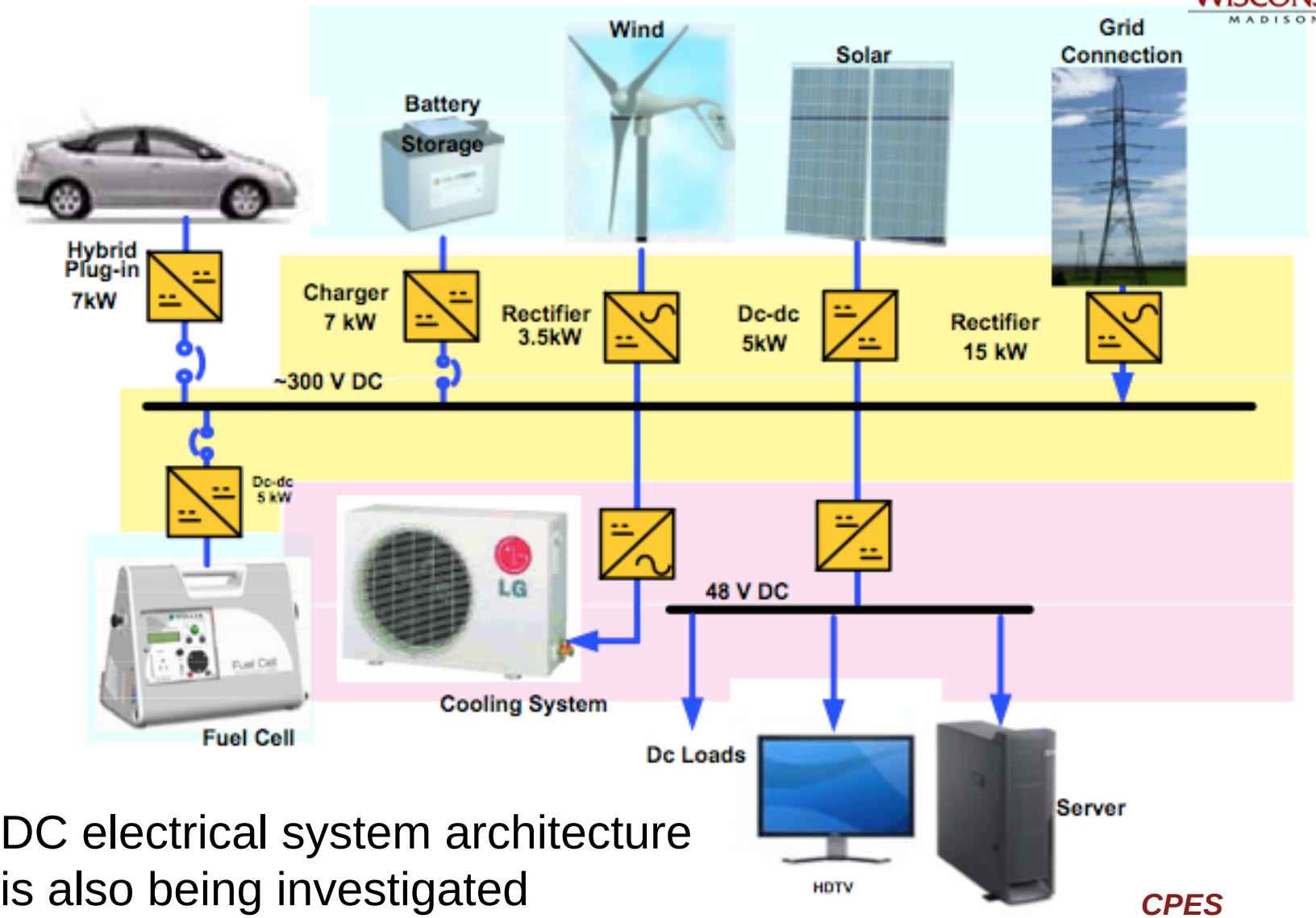
Testbed has been used to investigate and verify key Microgrid operating principles

UW High-Frequency AC Electrical System



- HFAC (600 Hz) under investigation as alternative to standard 60 Hz

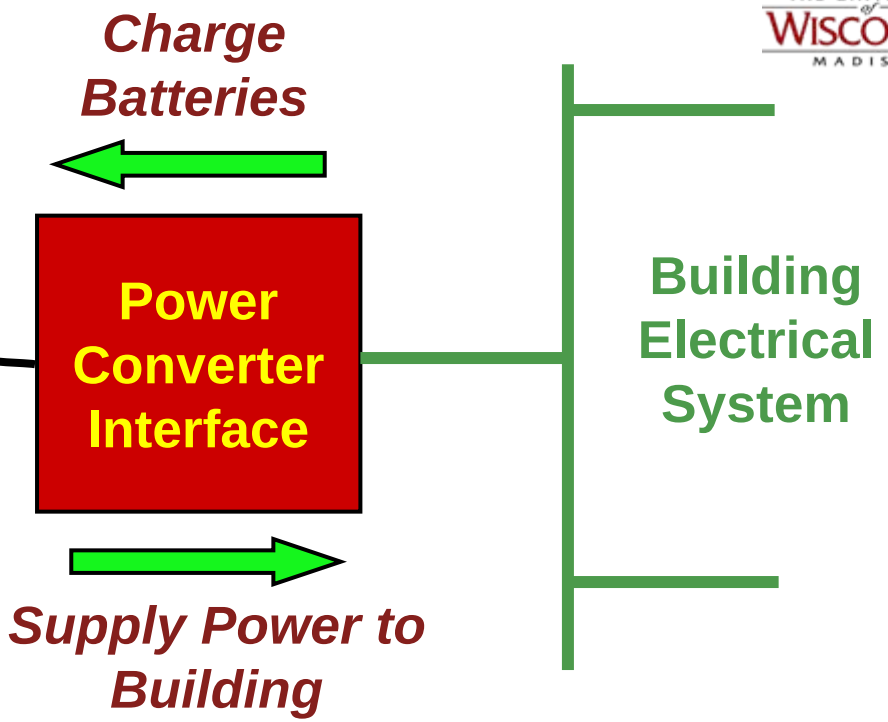
DC Electrical System Architecture



- DC electrical system architecture is also being investigated

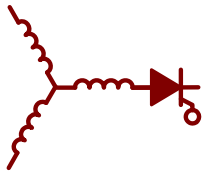
CPES

Plug-In Hybrid Vehicles

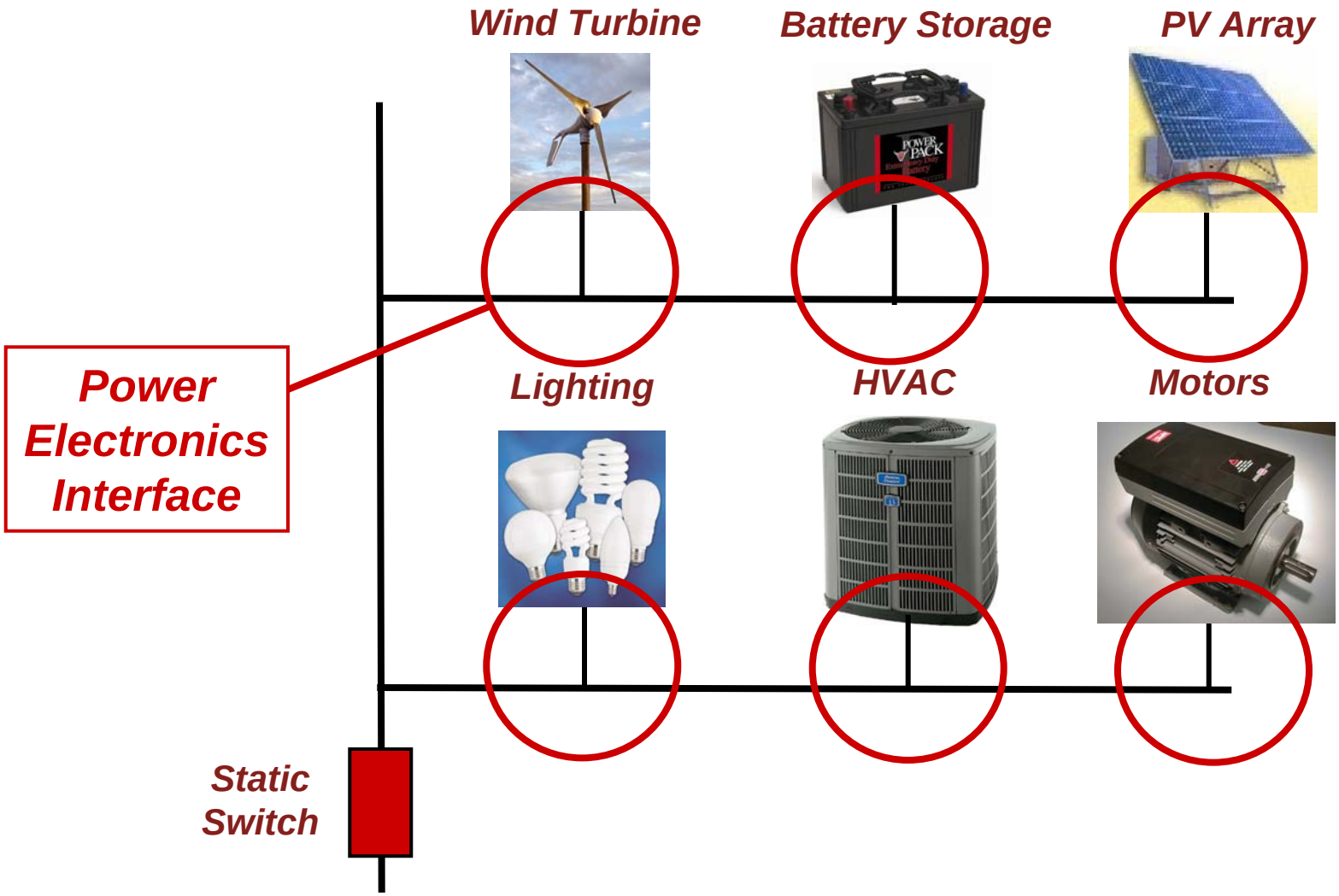


- Plug-in Hybrid Vehicles (PHEVs) represent opportunity for enhanced electrical system reliability and energy storage in future NZE buildings
  - Vehicles can serve as back-up generators when needed during islanded operation
  - Requires sophisticated control of bidirectional power flow between vehicle and building

Power Electronics and Motor Drives in Microgrids

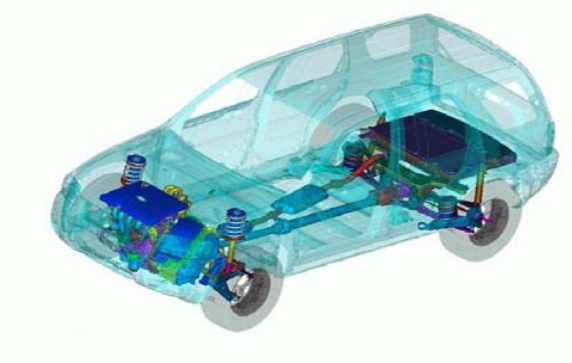


THE UNIVERSITY of WISCONSIN MADISON



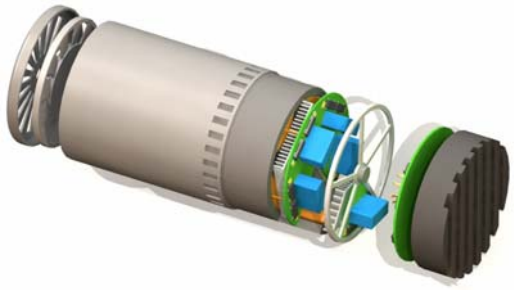
- Power electronics and drives are pervasive enabling technologies in microgrids

Power Electronics and Drives Technical Challenges

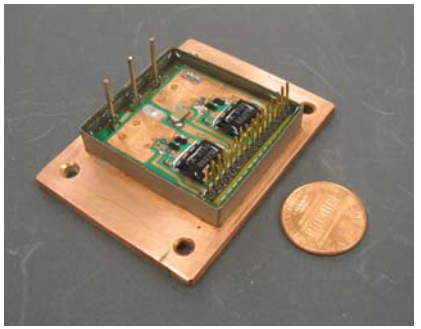


- ***Lower Cost***
- ***Lower Volume and Mass***
- ***Higher Efficiency***
- ***Higher Reliability***

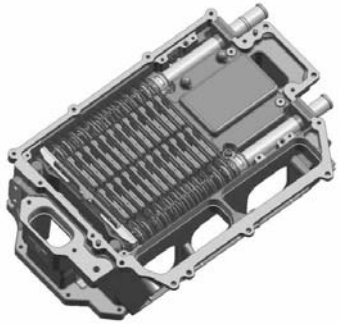
Power Electronics and Drives Technology Trends



- Increasing Levels of Integration
- Higher Voltage, Power, Frequency Operation

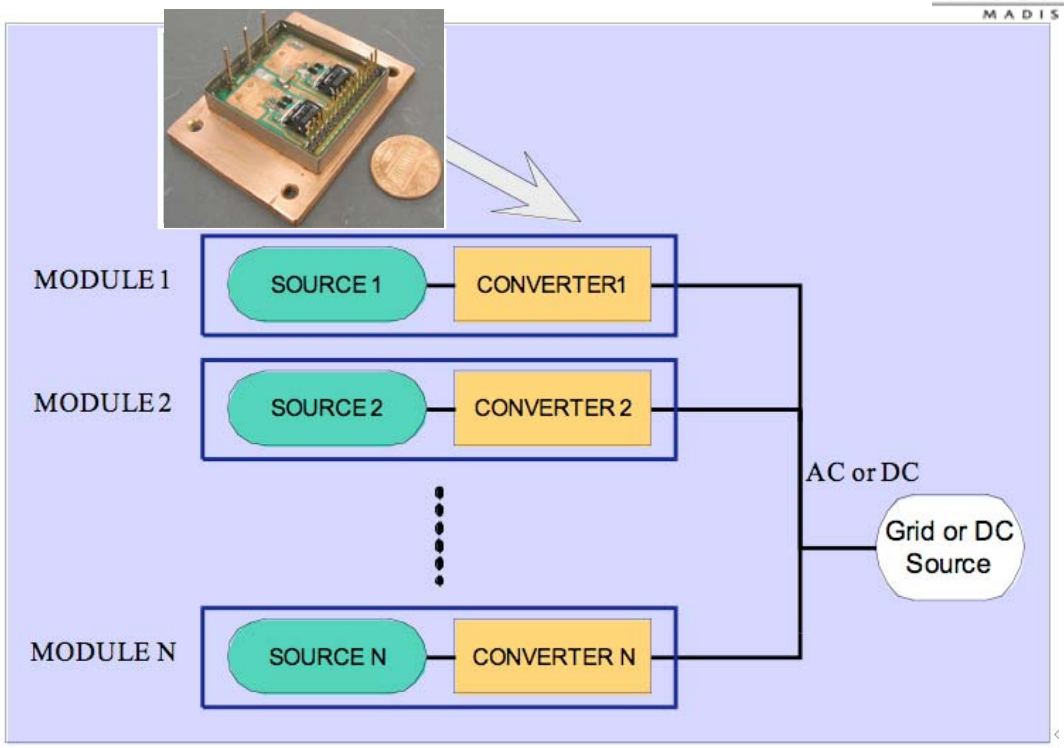


- Higher Operating Temperatures
- Higher Ratios of Silicon to Passive Components



- Higher Levels of Control Intelligence

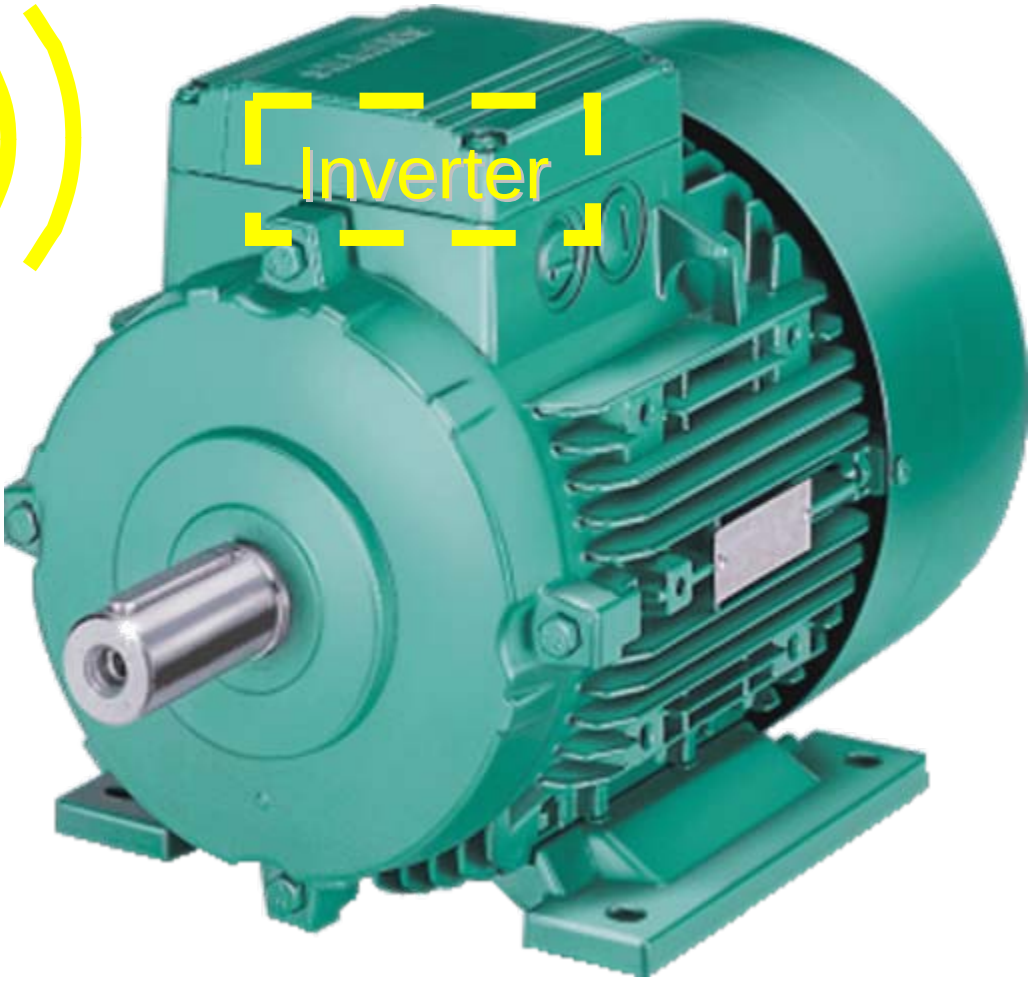
Solar PV Integrated Power Converters



- Integration of power converter directly into PV panels represents one promising approach to simplifying grid interface & improving protection
- Requires compact power electronics that is inexpensive and highly reliable in harsh thermal environments

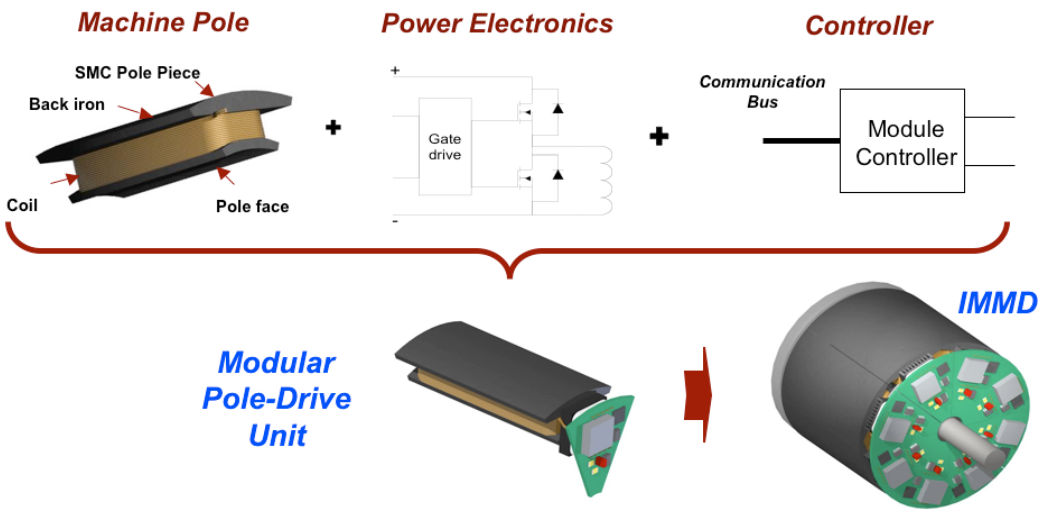
Integrated Motor Drives

Wireless Control

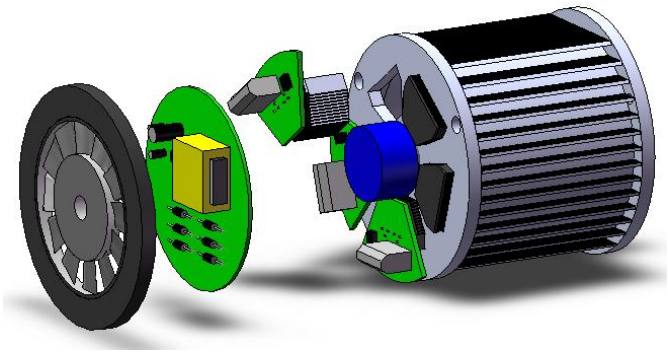


Integrated Modular Motor Drive (IMMD)

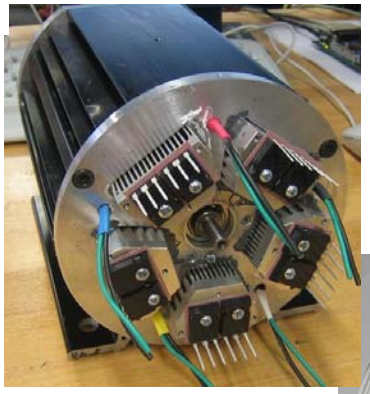
IMMD Concept



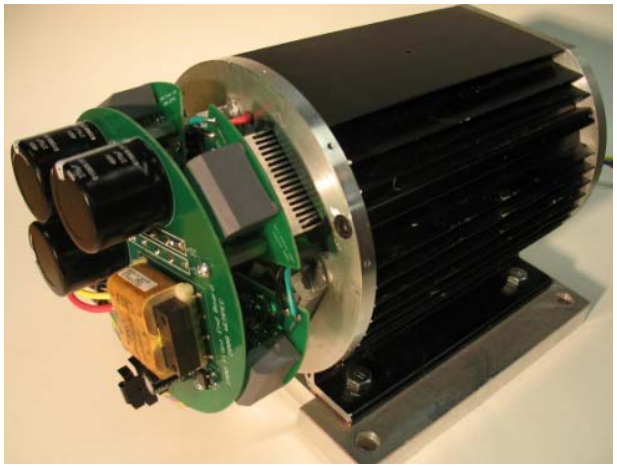
IMMD Demo Design



IMMD Demo Power Stage



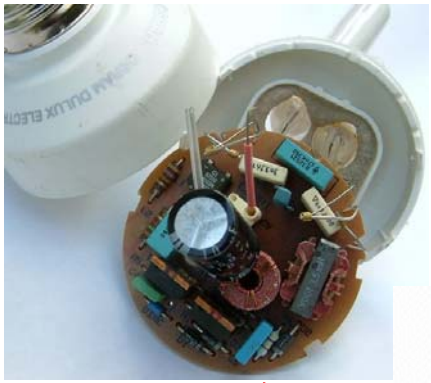
IMMD Demonstrator Drive



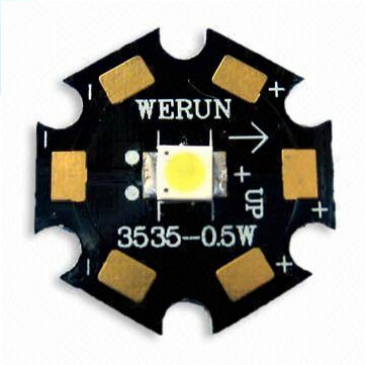
CPES

High-Temperature Power Electronics

Solar PV



Lighting

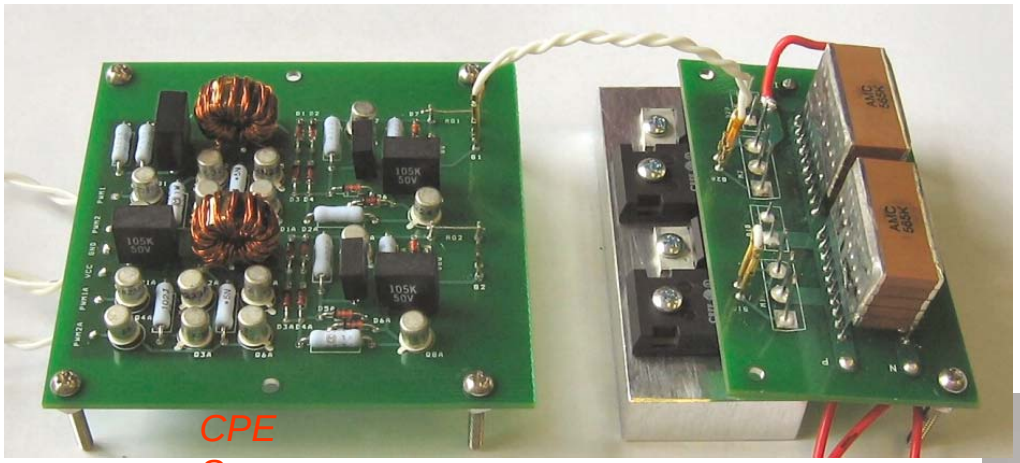


HiT Power Electronics

Motor Drives

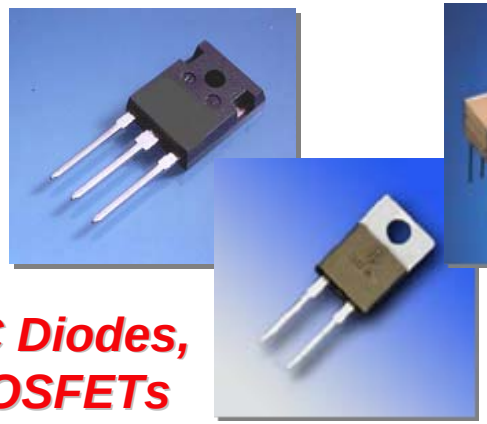
Vehicle

>150°C Inverter Operation

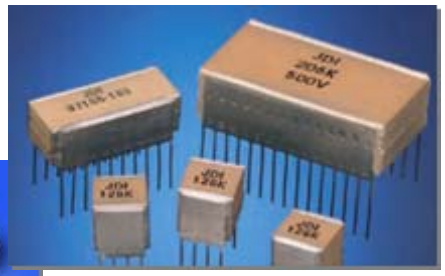


CPES

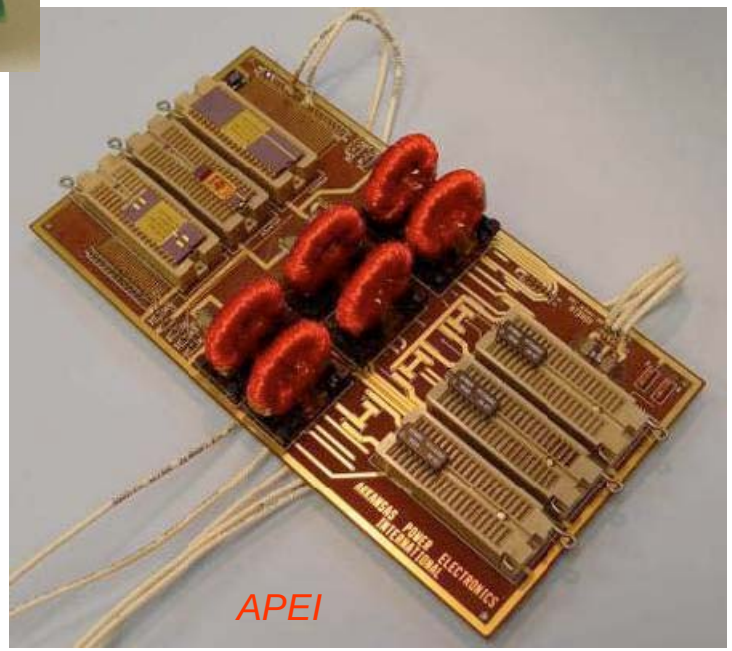
- Packaging is key to achieving reliable operation up to 200ºC
- Si or SiC are options



SiC Diodes, MOSFETs



Stacked Ceramic Capacitors



APEI

Recommended Paths Forward

Investment Priorities

- Establish NZE building/community electrical system testbed to develop/demonstrate microgrid concepts and advanced power electronics technology
- Accelerate integration of power electronics into key sources and loads (e.g., motor drives & PV)
- Champion development of high-temperature (>150ºC), high-reliability power electronics

Conclusions

- Success of NZE building initiative requires focus on electrical system issues from Day 1
- Power electronics and motor drives are key enabling technologies for NZE buildings/installations
- High priority must be given to driving down cost and boosting reliability of power electronics
  - Revitalize US power electronics industry in process

Military bases provide excellent NZE technology demonstration opportunities

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